

# Punnett Squares and an Introduction into Probability

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## *Integrating Math and Biology*

**Grade Level:** 7<sup>th</sup> (Middle School)

**Time Period:** This would take at least two periods to complete. Could be combined with a math period so that one period could be done during math and the other could be done during biology.

## **Content Standards**—

### **NGSS**

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Use and/or develop a model of simple systems with uncertain and less predictable factors.
- Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.
- Develop and/or use a model to predict and/or describe phenomena.

MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

*In grades 6-8*, students explain stability and change in natural or designed systems by examining changes over time, and considering forces at different scales, including the atomic scale. Students learn changes in one part of a system might cause large changes in another part, systems in dynamic equilibrium are stable due to a balance of feedback mechanisms, and stability might be disturbed by either sudden events or gradual changes that accumulate over time.

## **NYS Living Environment Standards**

1.1c In all environments, organisms compete for vital resources. The linked and changing interactions of populations and the environment compose the total ecosystem.

1.1d The interdependence of organisms in an established ecosystem often results in approximate stability over hundreds and thousands of years. For example, as one population increases, it is held in check by one or more environmental factors or another species.

2.1b Every organism requires a set of coded instructions for specifying its traits. For offspring to resemble their parents, there must be a reliable way to transfer information from one generation to the next. Heredity is the passage of these instructions from one generation to another.

## **NYS Math Standards**

- 7.PS.4 Observe patterns and formulate generalizations
- 7.PS.6 Represent problem situations verbally, numerically, algebraically, and graphically.
- 7.PS.9 Work backwards from a solution
- 7.PS.10 Use proportionality to model problems
- 7.PS.11 Work in collaboration with others to solve problems
- 7.RP.6 Support an argument by using a systematic approach to test more than one case
- 7.CM.1 Provide a correct, complete, coherent, and clear rationale for thought process used in problem solving
- 7.CM.3 Organize and accurately label work
- 7.CM.4 Share organized mathematical ideas through the manipulation of objects, numerical tables, drawings, pictures, charts, graphs, tables, diagrams, models, and symbols in written and verbal form
- 7.CN.5 Understand how concepts, procedures, and mathematical results in one area of mathematics can be used to solve problems in other areas of mathematics
- 7.CN.6 Recognize and provide examples of the presence of mathematics in daily lives
- 7.CN.7 Apply mathematical ideas to problem situations that develop outside of mathematics
- 7.CN.9 Recognize and apply mathematics to other disciplines, areas of interest, and societal issues
- 7.R.1 Use physical objects, drawings, charts, tables, graphs, symbols, equations, or objects created using technology as representations
- 7.S.8 Interpret data provide the basis for predictions and to establish experimental probabilities
- 7.S.9 Determine the validity of sampling methods to predict outcomes
  - Draw informal comparative inferences about two populations

## **Common Core State Standards (Math)**

- 7.RP Analyze proportional relationships and use them to solve real-world and mathematical problems
- 7.SP Use Random sampling to draw inferences about a population

### Content Objectives:

- 1.) Students will be able to use a computer modeling system
- 2.) Students will be able to apply math concepts into biology and real life situations
- 3.) Students will be able to create and decipher punnett squares

### Academic Language Demands

Vocab: Punnett square, probability, average, breeding, genetics, homozygous dominant, homozygous recessive, heterozygous, allele.

### Learning Tasks

**Mathematics:** Students will have already completed their probability and statistics section. They will begin the model by running the 3 different worksheets each 10 times for 30 seconds. Each time they run a trial they will record how many black baby bunnies and white baby bunnies are present. After finishing 10 trials they will be asked to average how many baby bunnies of each color were born during every trial. They will also be asked to figure the percentage of black and white baby bunnies out of the total baby bunnies born during the 10 trials. Next, they will record their information in a provided excel worksheet which gives the average and percentage answers. If the numbers do not match, students will use their partners to problem solve what went wrong. Next students will be asked to make line graphs in excel for their different data tables and compare the differences between the graphs – these will also be used as a visualization in the biology lesson.

**Biology:** Students will have already run the simulation in math class and will have the data table completed to bring to Biology. In the first 7-10 minutes of class I will go over the Mendelian genetic notes (which are attached to this document at the end). Students should feel comfortable about knowing what a punnett square is and what it is used for. After the notes are completed, we will move onto finishing the bunny worksheet. Students will be using the math data that they obtained to make 3 punnett squares. Each punnett square should have a different combination of the Bb alleles, one being a cross of BBxbb, another being a cross of BBxBB and the last being a cross of BxBb. They should figure this information out on their own with only little guidance from the instructor. You can give your students guiding questions throughout the worksheet by asking students “If one out of four of the squares is little “b”, what percentage is that?”. This will lead them to completing the correct punnett squares.

### Reflections

***Why is this lesson important?:*** This lesson is important in that it allows students to use computational models and math concepts and skills in the science classroom. Incorporating these skills into science is key for students to be able to apply what they are learning to real life situations. The modeling can be used in many different lessons and allows students to use engaging and fun tools while learning harder topics such as genetics.

***How will you assess student learning?:*** Students will be given a formative assessment in which they will have to submit one or two sentences about what they have learned from this lesson, specifically how learning the math first helped them understand the science more clearly.

***How will you use the concept of abstraction?:*** This computational model gives students a visual representation of probability and genetics. It makes it easier for students to understand difficult topics by allowing students to manipulate to model themselves.

***How will your lesson help students improve math and computational thinking skills?:*** It makes them understand the importance of science and math thinking skills such as performing multiple trials to find an average and the importance of this in the science world when real scientists are testing a concept. Our lesson plan also shows the importance of “backwards thinking”, where students start at the end product and work back to the beginning to find the answer to a problem. For example, rather than giving our students an already full punnett square and asking them to find the percentages of each genotype, we have the students figure out the percentages first then make the punnett square based off those calculations. Doing this helps students become prepared for real life situations.

Name \_\_\_\_\_

Class \_\_\_\_\_

### Punnett Squares

What is it?-- A punnett square is a graphic diagram used to predict the outcome of a particular crossbreeding experiment between two plants, animals, or anything that can mix genetic material by breeding.

Cross: Aa x Aa

	<b>A</b>	<b>a</b>
<b>A</b>	<b>AA</b>	<b>Aa</b>
<b>a</b>	<b>Aa</b>	<b>aa</b>

In this punnett square we can see two letters, each depicting a genetic trait. For most genetic discussions, capitalized letters stand for a DOMINANT trait where lowercase letters represent a RECESSIVE trait. Remember from our previous discussions what each trait stands for.

**HETEROZYGOUS:** this word represents the letter combinations in the above punnett square. "Hetero" stands for "different from", for example, a capital A and a lower case a are different from each other. Heterozygous individuals always display the dominant phenotype due to having one capitalized "A". The only way an individual will display the recessive phenotype is by having the homozygous recessive genotype (read below).

**HOMOZYGOUS:** "Homo" stands for "the same as", for example, two lowercase a's together or two capitalized A's together.

**HOMOZYGOUS DOMINANT:** when the two a's both represent the dominant trait and therefore are both capitalized. "AA"

**HOMOZYGOUS RECESSIVE:** when the two a's both represent the recessive trait and therefore are both lowercased. "aa". This is the only way an individual will show a recessive phenotype.

Run **New Rabbit 1** at about 75% speed 10 times for :30 Seconds and record the number of black and white baby bunnies created.

Number of Black and White Bunnies after :30 Seconds	<b>Black</b>	<b>White</b>
Trial 1		
Trial 2		
Trial 3		
Trial 4		
Trial 5		
Trial 6		
Trial 7		
Trial 8		
Trial 9		
Trial 10		

Find the **Average** number of black and white baby bunnies that are created during a :30 trial?

Average # baby black \_\_\_\_\_ Average # baby White \_\_\_\_\_

What are the total number of baby black bunnies from all 10 trials?

\_\_\_\_\_

What are the total number of white baby bunnies from all 10 trials? \_\_\_\_\_

What is the total number of Black AND White baby bunnies?

\_\_\_\_\_

Out of the total number of bunnies, what percentage were black baby bunnies? What percentage were white baby bunnies?

Insert your data table into the provided Excel worksheet New Bunnies. Do the excel calculations match? If not, what went wrong?

Run **New Rabbit 2** at about 75% speed 10 times for :30 Seconds and record the number of black and white baby bunnies created.

Number of Black and White Bunnies after :30 Seconds	<b>Black</b>	<b>White</b>
Trial 1		
Trial 2		
Trial 3		
Trial 4		
Trial 5		
Trial 6		
Trial 7		
Trial 8		
Trial 9		
Trial 10		

Find the **Average** number of black and white baby bunnies that are created during a :30 trial?

Average # baby black \_\_\_\_\_ Average # baby White \_\_\_\_\_

What are the total number of baby black bunnies from all 10 trials?

What are the total number of white baby bunnies from all 10 trials? \_\_\_\_\_

What is the total number of Black AND White baby bunnies?

Out of the total number of bunnies, what percentage were black baby bunnies? What percentage were white baby bunnies?

Insert your data table into the provided Excel worksheet New Bunnies. Do the excel calculations match? If not, what went wrong?

Run **New Rabbit 3** at about 75% speed 10 times for :30 Seconds and record the number of black and white baby bunnies created.

Number of Black and White Bunnies after :30 Seconds	<b>Black</b>	<b>White</b>
Trial 1		
Trial 2		
Trial 3		
Trial 4		
Trial 5		
Trial 6		
Trial 7		
Trial 8		
Trial 9		
Trial 10		

Find the **Average** number of black and white baby bunnies that are created during a :30 trial?

Average # baby black \_\_\_\_\_ Average # baby White \_\_\_\_\_

What are the total number of baby black bunnies from all 10 trials?

\_\_\_\_\_

What are the total number of white baby bunnies from all 10 trials? \_\_\_\_\_

What is the total number of Black AND White baby bunnies?

\_\_\_\_\_

Out of the total number of bunnies, what percentage were black baby bunnies? What percentage were white baby bunnies?

Insert your data table into the provided Excel worksheet New Bunnies. Do the excel calculations match? If not, what went wrong?

Graph 3 line graphs on excel with the 3 different data tables. What do you notice about the differences between the graphs?

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Why is it important to do multiple trials? Explain.

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Now that we've done the calculations, it's time to show your understanding of punnett squares. Below are 3 empty punnett square diagrams. For each simulation run (ex, new rabbit 1, new rabbit 2, new rabbit 3) you are to make a punnett square based on the mathematical results.

We need to ask ourselves the question "If the percentage of white rabbits for "New Rabbit 2" is \_\_\_\_\_ and the percentage of black rabbits for "New Rabbit 2" is \_\_\_\_\_, what would the alleles in the punnett square look like?

**example:** If the percentage of Black baby bunnies was approximately 75% and the percentage of White baby bunnies was approximately 25%, a punnett square could look like this:

	B	b	
B	BB	Bb	B= black b=white
b	Bb	bb	

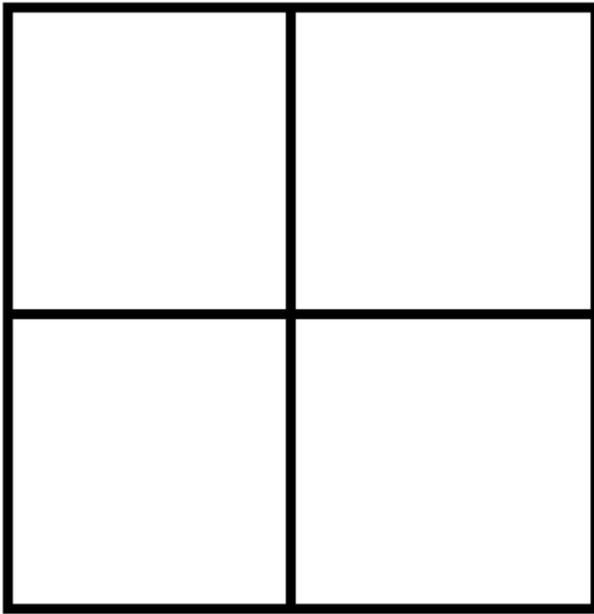
Each letter represent one allele.

What allele represents the dominant genotype? What is the dominant phenotype?

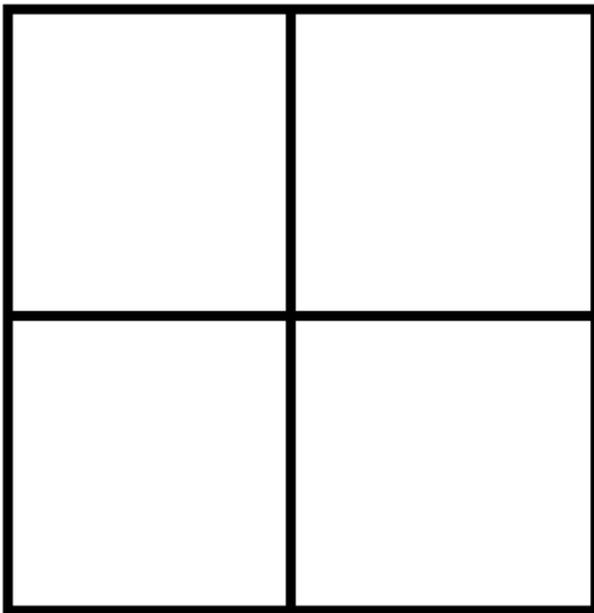
What allele represents the recessive genotype? What is the recessive phenotype?

As we can see, because only  $\frac{1}{4}$  of the squares represent the recessive phenotype, only 25% of the baby bunnies should be white. Because  $\frac{3}{4}$  of the squares represent the dominant phenotype, 75% of the baby bunnies should be black.

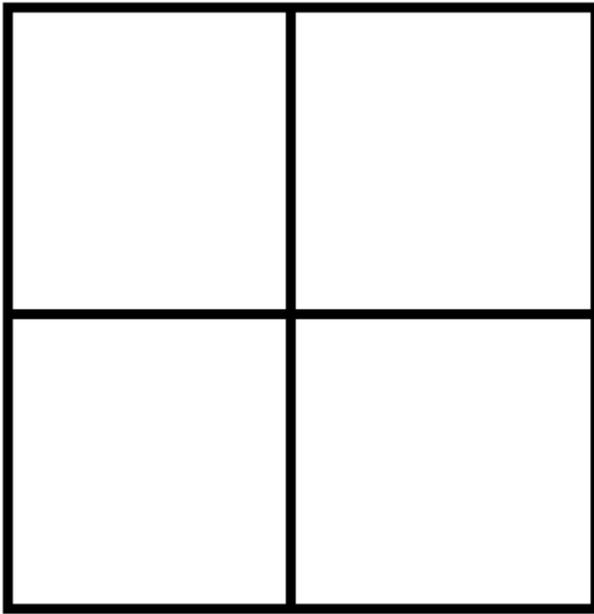
FOR EACH SIMULATION, PLEASE MAKE THE APPROPRIATE PUNNETT SQUARE



B= black  
b= white



B= black  
b= white



B= black

b= white